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Signed:
John W. Crosby

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: **WEHRUNG, et al.**		Examiner:	**To be assigned**
Serial No.:	**To be assigned**	Group Art Unit:	**To be assigned**
Filing Date:	**To be assigned**		
For:	**Distributed Control System Architecture and Method for a Material Transport System**		

PRELIMINARY AMENDMENT

Box PATENT APPLICATION FEE
Assistant Commissioner for Patents
Washington, DC 20231

Sir:

This preliminary amendment is directed to the Continuation Application filed herewith and is submitted in response to the Office Action dated September 6, 2000, a copy of which is attached for your convenience. Please amend the application as follows:

IN THE CLAIMS:

1. (Unchanged) A distributed control system for a material transport system, comprising:

a high-level controller;

at least one mid-level controller coupled to the high level controller; and

a plurality of low-level controllers coupled to the at least one mid-level controller;

in response to commands from a respective mid-level controller, each of the low-level controllers being configured to control directly a respective group of one or more electromechanical devices, the group being selected from a plurality of electromechanical devices composing the material transport system;

the respective mid-level controller being configured to formulate the commands in accordance with local goals formulated for the respective mid-level controller by the top-level controller;

the top-level controller being configured to formulate the local goals in accordance with a global goal for a transfer operation pending in the material transport system.

2. (Unchanged) The distributed control system of claim 1, wherein, when the global goal comprises a transfer command requesting movement of a particular package from one station of the material transport system to another station, the high-level controller determines a sequence of the local goals necessary to implement the transfer command and issues the local goals to the mid-level controller.

3. (Unchanged) The distributed control system of claim 2, wherein the local goals comprise a series of acquire, move and deposit commands that are executed by at least one of the mid-level controllers.

4. (Unchanged) The distributed control system of claim 1, wherein the material transport system comprises a transport system employed in a semiconductor fabrication facility to move at least one of:

one or more semiconductor wafers between processing stations;

one or more semiconductor wafers between the processing and metrology stations;

one or more semiconductor wafers between the metrology stations;

one or more reticles to respective ones of the processing stations.

5. (Amended) The distributed control system of claim 4, wherein the electromechanical devices comprise at least one of:

a zone including a length of track, at least one drive motor for driving a pod containing said wafers along the track, and at least one sensor for sensing presence of the pod within the zone;

a director for providing rotational movement between at least two zones whose track portions meet at other than a 180 degree angle; and

a Load Port Transfer Device (LPTD) for coordinating the pod into and out of the load zone.

6. (Unchanged) The distributed control system of claim 1, wherein the material transport system comprises a transport system employed in a manufacturing facility selected from a flat panel display manufacturing facility, a magnetic storage disk drive manufacturing facility or a pharmaceutical manufacturing facility, such that:

when used in the flat panel display manufacturing facility, the material transport system is used to move flat panels between flat panel components between flat panel manufacturing stations;

when used in the magnetic storage disk drive manufacturing facility, the material transport system is used to move magnetic storage disks between disk drive manufacturing stations; and

when used in the pharmaceutical manufacturing facility, the material transport system is used to move pharmaceutical components between pharmaceutical manufacturing stations.

7. (Unchanged) A method of configuring a distributed control system for a material transport system, comprising:

defining a set of neighborhoods including electromechanical devices composing the material transport system, wherein each of the neighborhoods includes the electromechanical devices that are likely to interact based on topology of the material transport system;

providing a low-level controller for the electromechanical devices, the low-level controllers being configured to translate generalized control commands to low-level control commands for the respective electromechanical device and to report status of the respective electromechanical device;

providing a higher-level controller that controls all low-level controllers associated with at least one of the neighborhoods via the generalized control commands;

compartmentalizing processing within the higher-level controller so that information regarding no more than the electromechanical devices composing the associated neighborhood is used to formulate the generalized control commands for low-level controllers associated with that one neighborhood.

8. (Unchanged) A computer program product for use in a material transport system including a plurality of electromechanical devices and a control computer, wherein the computer program product includes a computer memory coupled to the control computer and a computer mechanism defined therein, the computer mechanism comprising:

control threads that configure the control computer to control and monitor operations of the electromechanical devices;

one of the control threads associated with a particular electromechanical device communicating with others of the control threads associated with a group of electromechanical devices that interact with the particular electromechanical device so that the one control thread and the others cooperatively accomplish a goal involving movement of material using the particular electromechanical device and the group of electromechanical devices.

9. (Unchanged) The computer program product of claim 8, wherein:

the particular electromechanical device is a particular track zone and the group of electromechanical devices are other track zones neighboring the particular track zone, each of the track zones being configured to accelerate the material;

such that the one thread causes the particular track zone to accelerate the material to a target value, determines a set of future target values to which the material should be accelerated by the other track zones, and issues commands to the others of the control threads indicating respective ones of the set of future target values.

10. (Unchanged) The computer program product of claim 8, wherein the particular electromechanical device and the group of electromechanical devices form a neighborhood of the electromechanical devices likely to interact during operations of the material transport system.

11. (Unchanged) The computer program product of claim 8, wherein:

the material comprises a plurality of material units;

movement of each of the material units is independently controlled by the control threads; and

the control threads are configured so that the control threads that control the electromechanical devices composing a particular neighborhood in which a plurality of the material units are simultaneously moving can cooperatively accomplish a goal involving movement of the multiple material units towards respective destinations without collisions occurring.

Please cancel Claims 12 though 18.

19. (Amended) A distributed method for routing material from a source to a destination in a material transport system including track zones and directors connecting the track zones, wherein the directors include routing tables that store routing information in the form of distance data for a plurality of routes across the material transport system to a destination, the method comprising:

launching the material from the source;

when the material enters a track neighborhood that includes a director through which the material must pass to proceed to the destination, notifying the director of the approach of the material;

the director, in response to the notifying, selecting an optimal route for the material based on the destination and stored routing information indicating for each material transport system destination a director exit angle and a metric characterizing quality of a path to the destination originating from the director exit angle; and

the director subsequently decelerating the material, rotating to the director exit angle associated with the optimal route and relaunching the material along the optimal route.

20. (Unchanged) The distributed method of claim 19, further comprising:

modifying the stored routing information to account for routes that become unavailable during operation of the material transport system.

21. (Unchanged) The distributed method of claim 20, wherein a route becomes unavailable due to:

failure of the route's destination;

failure of a track zone between the director and the route's destination;

failure of one or more intervening directors between the director and the route's destination; and

disablement of the route by a material transport system operator.

22. (Unchanged) The distributed method of claim 19, wherein the metric associated with a particular exit angle and destination is determined for a new director as follows:

(1) the new director sends a path query to an immediate downstream neighbor at the particular exit angle;

(2) in response to the path query:

(2a) when the immediate downstream neighbor is the destination: the destination increments the metric to indicate the quality of the route to the destination and returns the incremented metric to the new director;

(2b) when the immediate downstream neighbor is a track zone: the track zone increments the metric to indicate the quality of the route through the track zone to the destination, resends the path query with the incremented metric to an immediate downstream neighbor of the track zone, which repeats operation (2); and

(2c) when the immediate downstream neighbor is another director: the other director increments the metric to indicate quality of the route from the other director to the destination and returns the incremented metric to the new director.

23. (Unchanged) The distributed method of claim 19, wherein the metric is a function of at least one of:

route length;

route transit time; and

route congestion.

24. (Unchanged) The distributed method of claim 19, further comprising:

(1) when a new destination is added to the material transfer system, the new destination announces its presence to its immediate upstream neighbor using a dest_announce message;

(2) in response to the dest_announce message:

(2a) when the immediate upstream neighbor is a track zone, the track zone increments a metric associated with the announce message that characterizes quality of a path from the new destination to the immediate upstream neighbor, resends the announce message with the updated metric to an immediate upstream neighbor of the track zone, which repeats operation (2);

(2b) when the immediate upstream neighbor is a first director: the first director increments the metric to indicate quality of the route from the first director to the new destination, stores the metric along with the exit angle and identify of the new destination and returns a registered message informing the new destination that it has been registered.

25. (Unchanged) The distributed method of claim 24, further comprising, when the immediate upstream neighbor is the first director:

the first director announces the new destination to adjacent directors with route_announce messages indicating a cumulative metric representing the metric from the first director to the new destination and the metric between the first director and respective ones of the adjacent directors;

repeating an operation wherein each of the adjacent directors updates their stored information for an appropriate exit angle with the cumulative metric and resends the route_announce message to their adjacent directors until the route_announce message arrives back at the first director.

26. (Unchanged) The distributed method of claim 19, wherein the stored information for each of the routes comprises:

the destination;

the exit direction;

whether the route is direct, meaning there are no intervening directors, or via, meaning there is at least one intervening director;

the metric characterizing goodness of the route; and

the route status.

27. (Unchanged) The distributed method of claim 19, further comprising:

when the material comprises two or more material units moving in one neighborhood in need of routing through the director, the track zones cooperatively route the material units to the

director so there is no possibility of a collision between the material units and the material units continue to move forward at optimal speeds.

28. (Unchanged) The distributed method of claim 19, wherein the track zones are unidirectional, further comprising:

configuring the transport system for bidirectional movement within one neighborhood by:

arranging a subset of the directors in a director cluster of two or more directors;

enabling exit angles for each of the directors in the director cluster to permit the material moving in one direction on a first unidirectional track zone segment in the neighborhood to be turned using two or more of the directors in the director cluster onto a second unidirectional track zone segment for movement in another direction in the neighborhood.

29. (Unchanged) The distributed method of claim 28, wherein the director cluster comprises a number of directors selected to prevent deadlock conditions where one or more material units needing to move through the director cluster are prevented from moving due to each others presence in vicinity of the director cluster.

REMARKS

This amendment directed to the Continuation Application filed herewith and is submitted in response to the Office Action dated September 6, 2000. Claims 12 - 18 in the parent case were allowed; consequently, claims 1 -11 and 19 - 29 were canceled in the parent case. In this Continuation Application, claims 12 - 18 are canceled; and claims 1 - 11 and claims 19 - 29 are pending and addressed herein. Applicant acknowledges with appreciation the Examiner's statement in the Office Action dated September 6, 2000, that Claims 24-25 would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Figure 1 has been amended in to add the designation "Prior Art," and is enclosed along with other formal drawings.

Claims 1 - 4 and 7 - 11 were rejected under 35 U.S. C. 102(e) as being anticipated by Jackson et al.

Applicant submits that the present invention is patentable over the cited art. A rejection based on 35 U.S.C. 102 requires that a single reference expressly or inherently disclose each and every element of a claim. Jackson teaches a transport assembly having sensor units that provide positional information of an object. Actuator units are arranged on the transport assembly for moving the object relative to the transport assembly. Computational units are arranged multi-hierarchically into groups for controlling motion of the object along the transport assembly. The groups of computational elements are coupled to selected ones of the sensor units and actuator units to define zones of control. Each zone of control overlaps with other zones of control to coordinate transition of control between computational elements as the object moves along the transport assembly. In contrast, Claim 1 of the present invention recites that the low-level controllers are configured to control directly a respective group of one or more electromechanical devices, the mid-level controller being configured to formulate commands in accordance with local goals formulated for the respective mid-level controller by the top-level controller, and a top-level controller that formulates local goals in accordance with a global goal for a transfer operation pending in a material transport system. Jackson does not teach or suggest this feature of distinguishing between local goals or global goals within a a hierarchy of controllers. Thus, the Applicants respectfully submit that Jackson does not disclose each and every element of the invention as claimed.

Claims 5 and 6 were rejected under 35 U.S.C. 103(a) as being unpatentable over Jackson et al. Applicants respectfully submit that the invention as claimed is patentable over the cited art. With respect to 35 U.S.C. 103 rejections, under the Graham test, three factors must be evaluated: the scope and content of the prior art; the differences between the prior art and the claimed invention; and the level or ordinary skill in the art. (MPEP 706 and 2141 et seq.). Skill in the art is that of an engineer in the field of computer technology.

Jackson does not teach or suggest levels of computational elements having the functional differences as claimed in the present invention; rather, Jackson *teaches away* from the present invention by disclosing levels of computational elements that perform similar functions.

In column 6 Jackson teaches that sensors and actuators can be coupled, directly or indirectly, to computational elements at *any* level in the hierarchy. Thus, the different levels of computational elements in Jackson are performing essentially the same function. In column 7 Jackson teaches that each computational element (first or second level) can calculate an actuator response. In contrast, the present invention as claimed includes three levels of computational elements that perform significantly different functions.

Jackson's definition of a computational element (i.e. something that takes in sensor data and transforms it into actual control signals), differs significantly from the computational elements as deployed in the different levels of the present invention as recited in Claim 1. In particular, Claim 1 of the present invention recites:

> "A distributed control system for a material transport system, comprising:
>
> a high-level controller;
>
> at least one mid-level controller coupled to the high level controller; and
>
> a plurality of low-level controllers coupled to the at least one mid-level controller;
>
> in response to commands from a respective mid-level controller, each of the low-level controllers being configured to control directly a respective group of one or more electromechanical devices, the group being selected from a plurality of electromechanical devices composing the material transport system;
>
> the respective mid-level controller being configured to formulate the commands in accordance with local goals formulated for the respective mid-level controller by the top-level controller;
>
> the top-level controller being configured to formulate the local goals in accordance with a global goal for a transfer operation pending in the material transport system."

Jackson teaches that the same decision is being made at differing levels, with higher levels overriding lower levels. As recited in Claim 1, the levels of computing elements of the present

invention provide very different functions from each other and are not interchangeable in contrast to Jackson.

Beginning at column 7, line 66, Jackson teaches that more than one computational element can, at any instant in time, have control over the object being moved. That is not the case in the system of the present invention, in which there is only one second level object that is in control of the material being moved. Jackson is not truly hierarchical, as the element(s) in control can be at any level.

In Jackson, each first level controller can receive commands directly from more than one second level controller. This is another significant difference from the system of the present invention, in which second level computational elements have direct control over only one first level object (i.e. the conveyor rail) as recited in the claims. If a second level computational element wants to control a first level computational element, it does so by communicating to the second level computational element in direct control of that first level computational element.

Jackson teaches a third level of computational elements that performs computations to calculate actuator responses. As described in column 8, lines 49 through 51, each third level computational element is coupled to five first level computational elements. This is a dramatic difference from the present invention, in which the third level of computational units does not have a role in calculating real time responses. Also, the third level components of the present invention do not coordinate a multiplicity of second level components.

In summary, Applicants respectfully submit that Jackson does not teach or suggest Applicants' invention.

Claims 19, 20, 22, 23, and 26 - 29 are rejected under 35 U.S.C. 102(b) as being anticipated by Van Essen. Applicants submit that the claimed invention is patentable over the cited art.

Van Essen teaches a sorting device provided with a transporting device for displacing objects such as postal items from an input station to an output position. The transport device includes a field of individual transport units arranged in a hexagonal grid shape and each provided with a transport

mechanism arranged on a rotatable support. The output positions are positioned alongside the field, while the field is accessible through at least two separate input positions.

The claimed invention as amended provides a method by which intelligent routing is performed dynamically by movement directors that are distributed throughout a transport system. The directors maintain routing tables that store routing information describing various routes along which material can be transported. Each director can evaluate its routing table and choose an optimal path to the destination based on distance data, and modify the route taken by material once it comes under the control of the director. In contrast, Van Essen does not disclose, utilize nor suggest any sort of dynamic routing that includes routing tables or distance data.

Claim 21 is rejected under 35 U.S.C. 103(a) as being unpatentable over Van Essen in view of Carter. The Examiner has directed attention to the rerouting means discussed in column 9, lines 33-42 of Carter. Carter teaches a lattice production line having a plurality of workstations each having a manufacturing robot, and outer turntable with workplace storage and an inner turntable aligned with the robot. I column 9, lines 33 - 42, Carter discloses that the system attempts to reroute workpieces when a fault occurs and initiates steps or corrections to alleviate the fault. However, Carter doesn't teach, utilize, or suggest the use of a routing table or distance data to perform dynamic rerouting of material as discussed above and recited in the amended claims. As Claim 21 depends from Claim 19, it is submitted that the amendment to Claim 19 overcomes the Examiner's rejection of Claim 23..

Claim 5 is rejected under 35 U.S.C. 112, second paragraph, based on antecedent problems with language in the claim referring to "the pod." Claim 5 has been amended to provide a proper antecedent basis.

Claims 24 and 25 are objected to as being dependent on a rejected base claim, but would be allowable if rewritten in independent form to include all the limitations of the base claim and any intervening claims. As discussed above, Claim 19 has been amended to more clearly indicate the difference over the prior art. As Claims 24 and 25, depend directly and indirectly from Claim 19, it is submitted that the amendment to Claim 19 overcomes the Examiner's rejection of Claims 24 and 25.

Attached hereto is a marked-up version of the changes made to the claims by the current amendment. The attached page is captioned "Version with markings to show changes made."

Based on the foregoing, Applicant respectfully submits that the application is now in condition for allowance. If any matters can be resolved by telephone, the Examiner is invited to call the undersigned attorney at the telephone number listed below.

Respectfully submitted,

9/03/01
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Version with Markings to Show Changes Made

5. (Amended) The distributed control system of claim 4, wherein the electromechanical devices comprise at least one of:

a zone including a length of track, at least one drive motor for driving [the]a pod containing said wafers along the track, and at least one sensor for sensing presence of the pod within the zone;

a director for providing rotational movement between at least two zones whose track portions meet at other than a 180 degree angle; and

a Load Port Transfer Device (LPTD) for coordinating the pod into and out of the load zone.

Claim 12 has been canceled.

Claim 13 has been canceled.

Claim 14 has been canceled.

Claim 15 has been canceled.

Claim 16 has been canceled.

Claim 17 has been canceled.

Claim 18 has been canceled.

19. (Amended) A distributed method for routing material from a source to a destination in a material transport system including track zones and directors connecting the track zones, wherein the directors include routing tables that store routing information in the form of distance data for a plurality of routes across the material transport system to a destination, the method comprising:

launching the material from the source;

when the material enters a track neighborhood that includes a director through which the material must pass to proceed to the destination, notifying the director of the approach of the material;

the director, in response to the notifying, selecting an optimal route for the material based on the destination and stored routing information indicating for each material transport system destination a director exit angle and a metric characterizing quality of a path to the destination originating from the director exit angle; and

the director subsequently decelerating the material, rotating to the director exit angle associated with the optimal route and relaunching the material along the optimal route.